

Development of Corrosion Resistant Current Collectors for Molten Carbonate Fuel Cells

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Introduction

Corrosion of steel components is a major problem in molten carbonate fuel cells (MCFCs). Bipolar plates and the current collectors, which are both made of stainless steel or nickel alloys are, undergo severe corrosion under MCFC operating conditions. Currently research is being done to improve the corrosion resistance of these components by applying a coating that protects the underlying steel against corrosion¹. Nickel electro cladding has been adopted as a technique to reduce corrosion on the anode side of the bipolar plate. However, nickel does not offer good barrier protection to the diffusion of oxygen. Aluminum coating provides corrosion protection in the wet-seal area. However, the poor conductivity of Al₂O₃ or LiAlO₂ scales discourages its use in the electroactive area.

Fe-Ni-Cr austenitic stainless steels 310S, 316 or 316L have been studied extensively for the cathode side.² The chromium in these alloys forms protective oxide layer, which prevents the whole alloy from being oxidized. However, chromium layer slowly reacts with the carbonate melt leading to a loss of electrolyte. This also results in an increase in the ohmic loss due to the formation of corrosion products on steel. Any improvement to the corrosion resistant properties of the current collector has to come by the way of novel coatings, which possess barrier properties to the oxygen diffusion. Also the coating should restrict the outward diffusion of steel components, a common problem associated with the Ni coating. The objective of this study is to develop a coating which provides effective protection against corrosion in both cathode and anode side of the bi-polar plate. The coatant, at the same time, should not induce any polarization loss.

In this work, the corrosion behavior of SS 304 under different gas conditions has been studied. SS 304 has been surface modified using encapsulation process with thin layers of nanostructured Ni-Mo and Ni-Co. A variety of electrochemical and physical characterization studies have been used to characterize the bare and surface modified SS 304.

Experimental

Electrodes of area 1 cm² were made from a perforated stainless steel 304 (Perforated Metals Inc.), with a void area of 45%. Gold wires were spot welded to the flat electrodes to serve as a current collector during electrochemical studies. The electrodes were cleaned before the characterization studies in order to be free of any contaminants.

Electrochemical studies were carried out using a three-electrode set up with gold as the counter electrode and Au/(2CO₂+1O₂) as the reference electrode. The reference gas flow rate was maintained at 10 cc/min. Oxidant gas with a composition of 67% CO₂ and 33% O₂ was directly purged into the carbonate melt. All the electrochemical studies were done using an EG&G PAR

model 273 potentiostatic interfaced with a computer. SEM was used to characterize the morphology changes during the oxidation of the SS 304.

Results and discussion

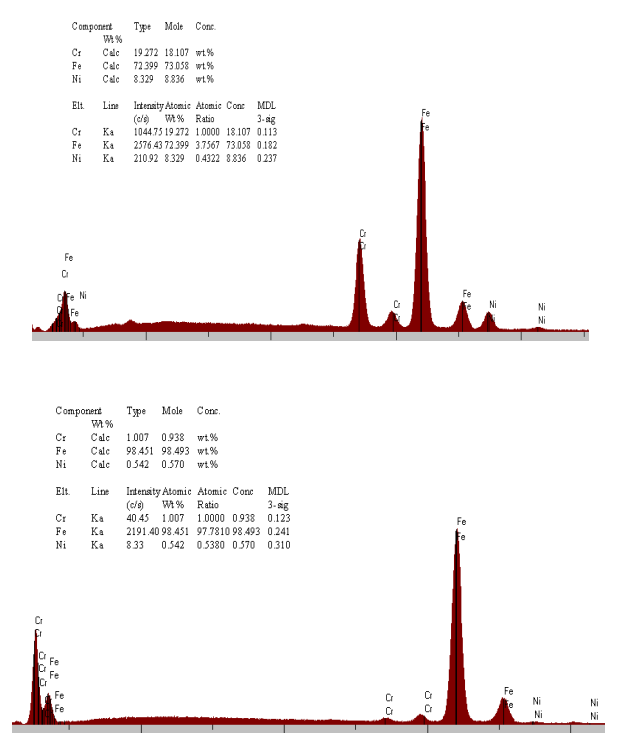
The corrosion of bare and surface modified SS 304 was studied under MCFC – cathode conditions at open circuit in different carbonate melts. The corrosion behavior was characterized using cyclic voltammetry. Under cathode gas conditions, chromium oxidizes to LiCrO₂ and dissolves in the melt. Iron oxidizes to FeO and nickel oxidizes to NiO. Corrosion rates were determined using Tafel polarization plots. Morphological and compositional changes were determined using SEM and EDAX. Detailed analysis of the corrosion scale formed in the case of bare and surface modified SS is currently being perfoemed. The corrosion protection and conductivity performance from MCFC point of view will be presented during the conference.

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References

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2 R. A. Donado, L. G. Marionowski, H. C. Maru and J. R. Selman, *J. Electrochem. Soc.*, **131**, 2541 (1984).



EDAX analysis on fresh (top) and oxidized (bottom) SS 304 current collector sample. Chromium depletion occurs after 24 h of exposure to the carbonate melt.